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U.S. DEPARTMENT OF AGRICULTURE

Clearing Land of BRUSH and STUMPS

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MANY farms have small tracts now in brush or inferior timber that would be more productive if cleared and used for crops. Also, many cultivated fields still contain large stumps that impede farm operations and add to the cost of crop production. Removing brush, trees, and stumps and preparing the ground for crops are at best laborious tasks. The labor in many cases, however, can be greatly reduced if proper tools and methods are employed. The method that succeeds best under one set of conditions may be wholly unsuited to others. Methods followed in different localities and the conditions under which their use is warranted are described in this bulletin.

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CLEARING LAND OF BRUSH AND STUMPS

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AS FAR back as history goes some part of the world's population has been engaged in clearing up new land and putting it into cultivation. It has been said that it takes three generations to make a self-sustaining farm out of cut-over land. Moreover, cleared lands are sometimes abandoned and must be recleared when again needed for crops.

Land clearing, therefore, is a problem in our oldest farming regions as well as in the newest settlements. Stumps left by the original or virgin growth still remain in many sections, and stumps of the second and even the third growth make land clearing a continuing problem in almost all agricultural regions. Clearing up land for the plow requires hard work, patience, experience, and usually the expenditure of a considerable amount of money.

It is impossible to give any figures of value as to the comparative cost of removing stumps by the various methods described or any figures on the average or usual cost of stump removal. So many different things affect the cost of stump removal that it varies widely. Even when the comparison is made with the stump rather than the acre as the unit, so many variations are found as to make the comparative figures valueless for other lands or for the same lands at other times. It has been thought that the volume of wood removed would be a good basis of comparison, but experiments show so much variation in root shapes and holding power, even among stumps of the same size and species, that comparative figures are almost valueless.

Furthermore, any cost figures are apt to be grossly misleading

because the most profitable kind of land clearing is that done with farm labor and equipment at odd times when no other productive work can be done, and the value of this labor is hard to determine. Ordinarily the value of anything is what it will bring on the market at the time it is available. Generally the labor and equipment used in crop production on the farm are available for land clearing for only short periods, possibly a few hours at odd intervals, and there is very little outside demand or market for such intermittent labor. It is unfair to charge the land-clearing operation with $1 per hour for the use of a tractor if the tractor is used only for short periods when it would otherwise be idle. The same reasoning applies to the use of labor, whether it be that of the owner himself or labor hired by the month or day.

NEED FOR CLEARING LAND

It is axiomatic that no farmer, either landlord or tenant, can make all the money he should until he gets his fields in the best possible condition to produce crops at low cost. No one who has held the handles of a plow in a stump field will deny that the cultivation of a crop among stumps is an expensive undertaking. A stump and its roots cause a great deal of lost time and broken equipment, occupy valuable space that should be yielding profitable crops instead of producing weeds to foul the entire field, and harbor injurious insects. Raising a crop on lands such as shown in figure 1 is very expensive, on account of the area lost to production and the high cost of cultivation.

Figure 1.—The cultivation of stump land is expensive.

Experiments carried on in Georgia show that under the same conditions it takes as long to plow 7 acres of stump field as 9 acres of cleared land. Thus the cost of plowing stump land is about

one-fourth more than that of plowing cleared land. Fourteen plow points were found in and around the roots of a lightwood stump in Mississippi. These plow points cost about $1 each, and the stump was blasted out at a cost of 30 cents. Under favorable conditions a field can be more cheaply cultivated with motor-drawn implements by plowing two rows at a time instead of one, but the most enthusiastic advocate of modern cost-saving machinery has never called a stump field a favorable place for its operation.

A surprisingly large number of farmers in cut-over areas have little chance to make money. These farmers are not confined to any one section or to any group of States. They must clear land to make it largely self-sustaining. Until the farmer has the minimum acreage of cleared land necessary for his particular farm, he must constantly work toward increasing his cleared acres if his farm is to become a self-sustaining economic unit.

The stump field and the underdeveloped farm are always disadvantages, but they are especially disastrous during "hard times" when the prices of farm products are low. At such times, to make a profit, every cultivated acre and the farm as a whole must be in condition to produce the largest possible crop at small cost. Clearing operations take considerable time, so that the landowner cannot wait for high prices to get his land in shape to produce a maximum crop. It follows then that land-clearing work during times of depression should be carried forward to completion as rapidly as can be done economically.

On most farms there are too many days when no productive labor is possible, and this is particularly true on underdeveloped and understocked farms. On such days, land clearing gives employment for labor that would otherwise be lost, for it can be economically and effectively done at odd times during intervals when farm labor is not required for crop production. The landowner does not have to wait until he sells his farm to obtain a valuable return from this labor, as he will receive a yearly return in increased crops and decreased cost of production.

Farmers will realize, of course, that there is some land that should not be cleared, because it will be more profitable if used for other purposes than agriculture.

DISPOSAL OF BRUSH

The first step in the preparation of cut-over land for cultivation is to remove the fallen logs and brush. The logs can be piled and burned or hauled off, and the undergrowth can be disposed of by grazing, cutting and burning, or plowing under. The principal factor in determining which method to use is the length of time the owner is willing to wait before putting the land in cultivation.

GRAZING

Grazing is theoretically an economical way to clear land of brush, and undoubtedly close grazing is effective in reducing the

cost of stump removal at the end of the pasturing period. Goats, sheep, and cattle are most frequently used for this purpose.

Goats are natural browsers, and there is no vegetation they will eat in preference to leaves and twigs. In practice, however, it has been found better to pasture cattle on the tract to eat up the grass, if it has been seeded, before turning in the goats. Sheep are the next best browsers, but they must be more closely pastured than goats, so that they will be forced to eat the bushes. In the cut-over lands of the Upper Peninsula of Michigan one ewe and one lamb will thrive on 1 acre of cut-over land during the open months and will keep down most of the sprouts. When either sheep or goats are grazing on large areas it is necessary to fence the land into small sections, concentrating the animals on each section for a short time until it has been browsed clean, then moving them to another, then back to the first, and so on.

Where grazing is depended upon to remove underbrush it is usually necessary to cut the brush that is too high for the animals to reach. Such work should be done as early as possible. The cut brush and trees can be piled with the fallen logs and burned or left to decay. For decaying, the cuttings should be left as they fall and not piled up, as brush in piles generally does not rot so readily as when scattered on the ground. A growth of grass aids greatly in keeping down the suckers and sprouts and hastens the decay of fallen brush. It also affords more feed for the stock, so that the standing brush is not eaten so quickly. It is advisable to go over the land at frequent intervals and cut down the growth that may be avoided or neglected by the stock in grazing.

The following method of pasturing has been followed with considerable success in southeastern Missouri: In summer or early in fall all small trees, brush, and undergrowth are cut down and left where they fall. In December a four-part mixture of grass seed, made up of timothy, orchard grass, redtop, and alsike, is sown by hand. The next spring, after the grass has a good start, cattle are turned into the field. One acre furnishes pasture for two head of cattle, but for short periods or in exceptional seasons five head per acre are pastured. The remaining timber is cut at convenient times, the merchantable timber and firewood hauled off, and the rest left to decay.

The cattle in feeding break down the dead tops, and the thickly growing grasses hasten the decay of all the wood on the ground as well as the stumps. Early in the fall of the fourth year the cattle are taken out of the field and the grass is allowed to grow as high as it will before frost. In winter, after frost has killed the grass, and during a dry time, the grass is set on fire. This fire is usually hot enough to burn completely all of the brush and down logs and partly consume the stumps. The stumps are then removed and the field is ready for plowing.

Pasturing cut-over lands not only keeps the brush down but makes stump removal easier. Trampling the earth as the cattle graze about the stumps compacts and solidifies the soil and seems

to work it away from the lateral roots, so that where land has been heavily pastured for some years the lateral-rooted stumps appear to be sitting on top the ground. The 18-acre field of the experiment station farm at Chatham, Mich., which was originally cut-over land, was burned over, then seeded to grass and heavily pastured with sheep for 7 years, and then cleared of stumps and prepared for plowing at a cost of $19.98 per acre. An adjoining tract, similar in all respects except that it was never burned, seeded, or pastured, was prepared for plowing at the same time, but at a cost of $115 to $125 per acre. This large saving was due in part to burning and in part to seeding and pasturing.

The practical advantages of pasturing, carried on mainly to remove the brush, are somewhat questionable. It requires investing a considerable sum in stock. This investment is subject to all the ordinary vicissitudes of the livestock business, and for the brush to be consumed it is necessary to underfeed the stock, which increases the risk of losing on them. Considered as a means of keeping down the brush and also making stump removal easier, seeding and moderately heavy pasturing is recommended when the land is not needed for cultivation for 3 or 4 years.

CUTTING AND BURNING

The most common method of brush disposal is to cut, pile, and burn it. This gets rid of the brush quickly, so that it does not interfere with the immediate cultivation of the land. Down logs, dead tops, and unmerchantable timber are worked up and removed or piled and burned as part of the brushing operation.

It is a common belief that brush cut in summer or early in fall is not apt to sprout again, but investigations have shown that there will always be some second and even third growth, regardless of when the brush is cut. To insure killing the growth it is generally necessary to go over the field at intervals and cut down the new sprouts. A good deal of brush is cut in winter, when other farm work is not so pressing and more labor is available.

Few tools are needed, but they should be in good working order. An ax, a brush scythe, or a bush hook are about all that is needed for cutting the brush. For handling the logs a team, a chain about 15 feet long, a 30-foot length of ½-inch cable, a crosscut saw, and a Swedish, or frame, saw are required.

The best piles of brush and logs are high and rather narrow, as shown in figure 2. Piling in small piles, fairly high, with the logs lying parallel is cheaper and better than making large piles, since the latter require additional labor, and if the pile is too large the fire may become so intense as to injure the fertility of the underlying soil. Logs and stumps should be burned separately, as much more compact piles can be made in this way.

In piling logs that cannot be readily handled, a team, cable, and two timber skids can be used to advantage. The pile is begun by passing a cable end under the log to be moved and hooking it to the log that is to be the center piece of the pile; the team, hitched

to the other end of the cable, rolls the log up to the pile by means of this rolling hitch. It is good practice to put two or more crosspieces under log piles to provide air circulation while the pile is drying out and a draft while it is burning.

Figure 2.—A log pile to be burned should be compact, narrow, and of good height, the unmerchantable logs lying parallel.

Sometimes the brush is piled in windrows to save moving it any considerable distance. To get a good burn such windrows should extend in the direction of the prevailing wind. Very large logs are most easily burned in place after splitting their ends with explosives.

As a rule, standing trees should be cut down before the brush is cut. It is generally better, especially where the trees are thick. to cut the tree and later remove the stump than to remove both tree and stump in one operation. It might be somewhat easier to pull a tree with a stump puller than to pull the green stump, on account of the greater leverage that can be obtained by fastening the pulling cable higher; and it might take but little more explosive to blast a tree than a green stump; but the fallen trees in thick woods occupy so much ground space as to increase greatly the difficulty and cost of the operation.

As a safety precaution, trees more than 6 inches in diameter should be felled first and then the stumps grubbed or pulled out. When a tree is pulled down with a tractor or other power apparatus, the cable used should be long enough to permit machine and operators to be at a safe distance. ***The minimum distance should be approximately three times the height of the tree.*** Each year men are injured when tops of trees or large limbs snap off and are thrown.

In this brushing operation any wood that is valuable for fire-

wood or other use should be removed from the field.[1] In splitting logs a splitting gun can be used to good advantage, especially for large logs in the West. Before attempting to use one, however, see the caution on page 28. The gun consists of a pointed steel cylinder, hollow for half its length, about 1½ inches in diameter and 18 inches long (fig. 3). A small charge of black powder is loaded into the pointed end of the gun, which is then driven into the end of the log, and the powder ignited. A small charge will split a large log into pieces that can be handled easily by one man. The gun should be driven into the center of the log, or into solid wood; knots, rotten spots, and cracks should be avoided. The same results can be obtained by boring a hole in the end of the log and tamping the small charge of explosive in it.

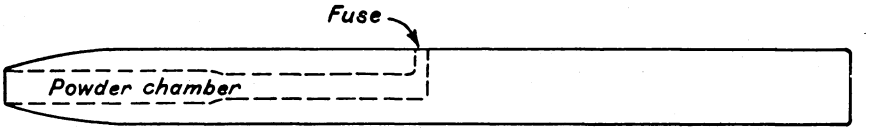

Figure 3.—Splitting gun, especially useful for driving into the ends of large logs.

In some southern-hardwood sections the general custom is to cut and burn the brush, deaden the trees, and put the land in cultivation. The deadened trees remain until they become so weakened by decay that they are blown down and later are piled and burned. The stump is not removed until it becomes so rotten that it can easily be grubbed out. As the decay may take 6 to 10 years, and as the farming operations during all this time are carried on under great difficulties, it is doubtful whether this method is truly economical, although it requires less expenditure of labor and money than removing the trees. Unless the dead standing trunks can be burned in place, as is sometimes done, it costs almost as much to remove them after they decay and fall as when they are green. Leaving the deadened trunk in place will not hasten the decay of the stump or make its removal cheaper.

Burning standing and live brush is of great value in destroying it and also in reducing the cost of stump removal. ***Fire in a cut-over country is always dangerous and should be started only after making complete and detailed arrangements for controlling it.*** In many States it is necessary to procure a permit from the local authorities before a woods fire may be started, and there are certain seasons when such permits cannot be obtained. A large percentage of the devastating forest fires in cut-over sections originate in land-clearing fires. ***Great care, watchfulness, and strict compliance with the law are necessary.***

The comparative hours of work required per acre in brushing, piling, and burning on two tracts of land in Minnesota, one burned over and the other unburned, also the labor required to remove

[1] See Farmers' Bulletin 1210, Measuring and Marketing Farm Timber.

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the stumps and the explosives required for blasting them are given in tables 1, 2, and 3.[2]

TABLE 1.—*Work required per acre for brushing, piling, and burning brush on burned and unburned land in Minnesota*

Operation	Green timber		Burned timber		Saving in man labor due to burning
	Man-hours	*Horse-hours*	*Man-hours*	*Horse-hours*	*Percent*
Brushing	63.3	-------	38	-------	40
Felling, trimming timber	80.5	-------	67.5	-------	16.1
Burning brush	9.9	-------	14	-------	41.4
Miscellaneous operations, skidding logs, poles, etc	65	37.5	35.6	37.8	45.2
Total	218.7	37.5	155.1	37.8	-------

TABLE 2.—*Comparative labor units per acre required in disposing of stumps in Minnesota*

Item	Green unburned		Green burned		Dry unburned		Dry burned	
	Man-hours	*Horse-hours*	*Man-hours*	*Horse-hours*	*Man-hours*	*Horse-hours*	*Man-hours*	*Horse-hours*
Blasting	30.8	------	7.1	------	7.7	------	2.3	------
Piling refuse material	13	------	5.2	6.3	14.4	28.8	1.7	1.9
Pulling, piling small stumps	0	------	25.9	25.8	17.4	34.8	22.1	21.8
Pulling, piling after blasting	35	69.5	22.2	22.6	44.3	88.5	18	16.7
Burning	3.6	------	2.9	------	1.5	------	2.9	------
Total	82.4	69.5	63.3	54.7	85.3	152.1	47.	40.4

TABLE 3.—*Explosives and materials used per acre in blasting out the stumps in Minnesota*

Item	Green unburned area	Green burned area	Dry unburned area	Dry burned area
Dynamite ---- pounds	171	62.9	41	14.4
Caps ---- number	211	86	57	29
Fuse ---- feet	313	150	92	46

Little detailed information is available as to the effects of forest and brush fires upon the fertility of the soils. It is known that

[2] From Minn. Agr. Expt. Sta. Bul. 220, Effects of Forest Fires on Land Clearing and Crop Production.

such fires will add to the productivity of peat and muck soils, while it is likely that injurious effects are sometimes suffered by other soil types when used for certain crops. Minnesota Agricultural Experiment Station Bulletin 220 says:

> Comparing crop production on the burned virgin soil (upland clay) with production on like soil unburned, sunflowers produced equally well or better; hay about as good; oats and potatoes distinctly less. Clover catches remarkably well in the ash.

In eastern North Carolina large areas of swampland have been drained and prepared for cultivation by burning the brush. All the merchantable timber, consisting of original growth of pine, cypress, gum, juniper, maple, and poplar, has been cut out, but the remaining unmerchantable timber and underbrush are very thick. The soils vary from heavy black loams to peat or muck, and generally there is a layer several inches thick of turfy vegetable matter on top the ground. For several years the approved method of getting this land into cultivation has been as follows:

Late in summer or early in fall all the growth is cut down and allowed to lie where it falls. This growth is so rank that when it is cut it often forms a continuous mat, sometimes 6 feet thick, over the entire field. When labor was $1.50 per day, the cost of cutting down the brush was $8 to $10 per acre. During May of the following spring the brush is set on fire. A satisfactory burn is one that destroys all the brush, a large part of the logs and stumps, and all the turf.

While the ground is still hot from the fire, corn is planted by hand among the remaining logs and stumps. If a sufficiently good fire has been obtained, few weeds will appear and no cultivation will be necessary. When the corn is ripe it is picked and carried in sacks to the edges of the field, or roads for hauling it can be cut through the down logs. During the winter the down logs and loose stumps are piled and burned. This program is repeated for 4 years before the field is plowed. More weeds appear each year and more hoeing has to be done to keep them down, but more logs, roots, and stumps are removed, thus giving more space for corn and making harvesting easier.

The fourth year finds the ground sufficiently free of debris to allow rough plowing with a disk plow and raising the crop in the usual manner (fig. 4). For a number of years roots and pieces of stumps will be turned up after each plowing, so that piling and burning or hauling wood out of the field is necessary until the field is entirely clean. It is claimed that under the conditions in this section, the corn grown each year during the four preparatory years before plowing yielded 30 to 40 bushels per acre. Such a method of land clearing can be economically followed only where labor is cheap and abundant. Its success is largely dependent upon the thoroughness of the initial burn, and it is not always possible to get a good burn.

Some farmers who have tried the above method favor the following variation: Cut and burn the timber, but allow the land

to grow up to weeds for 4 years. In the fall of the fourth year the weeds and new brush are cut and the stumps and down logs piled so that all can be burned off, and the field plowed the next spring. It is claimed that the rank growth of weeds keeps the sunlight from drying out the logs, brush, and stumps and so hastens their decay; that this method preserves more of the fertility of the soil; and that the cost of the entire operation is less than the net cost where a crop is planted among the partly burned logs and stumps. This method, however, has not been given a thorough trial, so that it is not definitely known that it has any advantages over the older method.

Figure 4.—Cornfield in a burned area before all trunks and stumps were removed.

In the Delta section of Mississippi, where the growth is largely gum, with some oak, hickory, and maple, the following plan has been used: After the merchantable timber has been removed, the remaining trees and brush, which are usually dense and of heavy growth, are cut down in spring, after the leaves are out. This work is usually let out by contract and when labor was $1.50 per day generally cost about $10 per acre. The next fall, after the weeds have been killed by frost, the entire field is burned over. The logs remaining from this fire are pulled together by a log skidder, piled, and burned. The next step is to gather the unburned treetops, underbrush, and debris to be burned. A two-horse hay rake is used for this work, which is hard on the rake

but does gather up the loose material cheaply. The stumps are left in place to decay, which takes 1 to 8 years, depending on kinds and sizes and the extent to which they have been burned. After the first plowing the field is again raked over to collect the roots brought up by the plow.

In the arid sections of the Western States the principal growth that must be removed prior to cultivation consists chiefly of greasewood, sagebrush, mesquite, manzanita, and chaparral. Under certain conditions of climate or fertility of soil some of these shrubs approach tree size and in such case they can be removed by any of the methods here described for removing stumps and trees. Where they are not more than 5 to 6 feet high they can be railed, piled, and burned. The railing is done by breaking off the bushes with a railroad rail, a heavy log, or a piece of timber with a steel cutting edge, dragged across the field by two or more two-horse teams hitched to the ends. The field is usually gone over twice but in opposite directions. It is most easily done when the ground is frozen.

The stumps that remain are then grubbed up, or left to be plowed up, and the brush is raked into windrows and burned. A brush rake can be made of a 6-inch timber, 12 feet long, by boring 2-inch holes through it, 10 inches apart, and inserting in each a wooden tooth about 3 feet long. The rake is then fastened by two timbers to the rear of a wagon to which a team is hitched.

In the Eastern States a number of trees are hard to destroy on account of peculiar root systems and a strong, persistent capacity for reproducing themselves. Sassafras roots strike perpendicularly into the ground for approximately 8 to 16 inches, then turn at right angles, rarely both ways, and pursue a horizontal course for about the same distance, when they split into numerous lateral feeder roots. The usual method of cutting these roots off several inches below the ground serves only as a temporary expedient. The most satisfactory method of dealing with sassafras is to pull it out. Any clamp device will work if adjusted to a stout handle 5 to 6 feet long in such manner as to give a strong leverage. The sassafras can be exterminated in one grubbing if the root is followed and cut beyond where it makes the angle, but this method is laborious. Constant and careful plowing—maintained for several years—will gradually exterminate this bush, but the condition of the soil will not usually permit continuous plowing.

Persimmon and locust are very similar to sassafras and should be treated in the same way. The locust roots are a little nearer the surface, and more numerous, slender, and tenacious than the other two mentioned. Alder should be cut off in August at or below the crown, left where it falls, and burned the following spring.

PLOWING

In some places where stumps are few and far apart it is possible to plow the brush under and immediately put the land in crops.

All trees more than 2 or 3 inches in diameter or more than 6 or 8 feet high should be cut down and all stumps more than 6 inches in diameter removed before plowing is attempted.

Plows of a great variety of kinds and sizes are being used for this work, depending in part on the growth and soil and in part on the owner's opinion of the results obtained with the various makes. Although it would be possible to hitch enough horses to the plow to pull it, they would not be as effective as a tractor in breaking down the brush and small trees. The size of the tractor depends on the power required. The smaller ones seem to give satisfaction where the work is within their pulling range.

For heavy brush, the tractor should be strong in all its parts. It should have a large bottom clearance in order to pass readily over small stumps, debris, and stones, and the driving wheels should be equipped with extension rims and strong lugs. Some operators prefer to hitch the tractor to the plow with a chain about 10 feet long, to give the plow greater flexibility, while others prefer a rigid but adjustable attachment so that the plow can be backed up when it gets wedged under a stump.

Figure 5.—A type of plow used for turning under brush.

The plows and coulters are of many designs, but a single-bottom plow 20 to 24 inches wide, with a landside about 5½ feet long and 6 inches in width for large plows, and some form of standing coulter, seems to be the most popular. It is important that there be 20 to 26 inches of clearance at the throat of a plow to avoid having to stop too frequently to clear the plow of brush and debris. A type used for plowing under brush is shown in figure 5. The division of agricultural engineering of the University of Wiscon-

sin has developed a brush plow with a throat clearance of 26 inches and an offset in its beam that holds the plow bottom some 8 inches on the right side. This permits the space directly in front of and above the plow to remain relatively free so that most of the brush is caught and turned under by the rolling action of the furrow slice. A standing cutter, the upper end of which curves backward and to the right, was also designed to further prevent choking.

A compilation of the returns from a questionnaire sent out some years ago to Minnesota farmers gave the following information as to the equipment used for plowing under brush in that State:[3]

Average drawbar of tractors	horsepower	15.25
Average size of cut	inches	27.50
Average depth of breaking	do	6.30
Average clearance of plow	do	21.00
Average cost of fuel, oil, and labor per 10-hour day:		
Gasoline or kerosene		$5.27
Oil and grease		1.39
Labor, at 40 cents per hour		9.00
Total		$15.66
Average cost per acre		4.24

Other information thus developed was that the best time for plowing under brush is June, July, and possibly August; that where brush has been plowed under, the land can be plowed a second time within 2 or 3 years after the first breaking; that more satisfactory work can be done when the ground is comparatively dry than when it is very wet; that after plowing, the fields can usually be disked and sown to flax, hay, or grain; and that the crops grown for the first 2 years may equal those raised under normal methods of cultivation if all conditions are favorable.

Some especially large and heavy plows made for this purpose will plow 15 or 18 inches deep, but they are expensive to operate. In some soils such deep plowing is not advantageous.

Where conditions are favorable for plowing brush under, the operating cost is undoubtedly less than the contract price of cutting, piling, and burning. The cost of a plowing outfit, however, is great, the plowing season is short, and there is little other employment about a farm for such heavy equipment. This method of brush disposal, therefore, is not economical for the farmer who desires to put only a few acres into cultivation in any one year.

Furthermore, when the brush is thick and heavy, the plowed surface is usually very rough and uneven, so much so that for several years plowing is difficult. If the brush is well covered it will generally rot rapidly, although at least one case is on record where the farmer had to dig up and pull out most of the brush when he tried to plow the field the first year following brush plowing. Usually many roots and brush are left uncovered and exposed to the air. This prevents early decay and interferes seriously with

[3] Minn. Agr. Expt. Sta. Bul. 208, Investigations in Stump and Stone Removal.

plowing for several years. Where brush plowing is done, it is generally best to seed the tract and keep it in hay or pasture 3 or 4 years.

In parts of several Southern States the scrub, or saw, palmetto is the principal undergrowth. This plant has a strong horizontal root that grows along or under the surface of the ground, and from this root a large number of vertical feeder roots extend down into the soil. Formerly the palmetto was grubbed out by hand at great cost, but usually it can be plowed under with a heavy breaking plow. When the horizontal roots are more than 3 inches in diameter and are present in considerable numbers it is almost impossible to turn them under with the ordinary plow.

A plow that has been used with some success for this purpose has a vertical cutting edge like a heavy standing coulter beneath the beam. At its lower end, about 4 inches below the ground, are two horizontal knives 18 inches long and extending at an angle of 45° in both directions. After this plow has cut off the feeder roots the palmetto can easily be pulled by hand and thrown into wagons to be hauled off and burned. A small tractor and plow can cut off about 2 acres of palmettos in a day and a large tractor about 3 acres.

STUMP REMOVAL

GRUBBING

The earliest and most primitive method of stump removal, that of hand grubbing, is still used extensively despite the fact that the work is hard and tedious and men cannot be hired to do it so long as they can get easier jobs. For stumps up to 6 or 8 inches in diameter grubbing is generally the most effective and economical method of removal. As the size of the stump increases, the economy of this method tends to decrease, but where labor is cheap the costs are not excessive, even on large stumps.

A South Carolina planter says that during the winter of 1921–22 he paid out $400 for grubbing stumps at a cost of 10 cents each, but that 2 years earlier he could not have contracted this work for $2 per stump, as men would not do such work at any price during prosperous times. In the summer of 1922 the contract price for grubbing in the Mississippi Delta was 25 cents per stump. In southwestern Texas when labor was plentiful grubbing out mesquite could generally be contracted for at $15 per acre.

The tools required for grubbing are an ax, a grub hoe or mattock, and a shovel. The advantages of grubbing out stumps are that it requires no investment in new tools or equipment, it can be used equally well on stumps that are thick or scattered, green or dead, rotten or solid, and that it makes a clean job of removing the roots. The disadvantages are that it is slow and laborious, for large numbers of stumps it requires either many men or a long time, it leaves the stump and roots in such shape that the large ones are hard to handle and dispose of, and where labor has to

be hired at high rates it is expensive. Although other methods of removal may be quicker and easier, unless the labor so saved can be put to some profitable use, nothing has been gained by saving time. Large numbers of stumps are being removed by farm labor during intervals when no other farm work is pressing, and under such conditions the grubbing method is profitable.

BURNING

Fire, one of the oldest methods of destroying stumps, is still used to good advantage under many conditions. Although it is a comparatively simple matter to build around a stump a fire that will consume it, it is extremely difficult to burn the roots to a depth where they will not interfere with cultivation. The usual minimum depth required, so as to be beyond any probable plowing depth, is 18 inches, since the ground about the stump is frequently higher than the general surface and since there will be considerable settling of the ground when the stump is removed.

To obtain a good fire, the heat should be confined and conserved as much as possible and the air supply limited to just what is required for combustion. Stumps are burned with free or open draft, by charpitting, and by devices for obtaining forced draft.

Occasionally it is possible to build on the outside of a stump a fire that will burn so readily as to destroy most of the roots. Usually it is necessary to get it into the center of the stump, where little heat will be lost by radiation. With the taprooted pine stumps of the South, which seldom exceed 30 inches in diameter, the general method of burning is to dig a hole 15 to 18 inches deep and about a foot wide on one side of the stump, down along the taproot, and then to bore a hole from the surface of the ground on the other side of the stump into the bottom of the dug hole. This hole should be about 2 inches in diameter, for smaller holes sometimes become choked with soot. A fire is started with brush in the bottom of the dug hole, and as the draft through the bored hole draws the fire into the stump, the whole stump will soon be blazing.

A small quantity of brush piled around the burning stump will increase the draft and heat, but if too much is used it will keep the air away from the fire and the outside of the stump will become so charred that it will not burn completely. It is best to have only a small fire and to keep it going by frequent attention. It takes 24 to 36 hours to burn a dry stump, and if the stumps are not too widely scattered one man can keep about 75 burning.

Some burners watch their fires throughout the night, but if only a few stumps are to be burned and the fires are started early in the morning only one rebuilding at night is required. Both stumps and ground must be dry to obtain good results, so this work can be done only when the weather conditions are right. A heavy rain may put out the fires, and when this occurs they are hard to start again.

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When this method is used on the large stumps of the West, two or more holes are bored into them. One is bored down the center to a depth of a foot below the ground surface and a second, begun at or below the ground level and piercing one of the large roots, is bored so as to intersect the first near its lower end. The fire is started at the junction of the two holes with a hot iron, a glowing coal, or a blowtorch. A hand bellows is very useful in getting a blaze started.

These bore holes may be made either by hand or with a power-driven auger. As the holes are usually of considerable length it is a tiresome task to bore them by hand and takes considerable time, but power-driven augers are expensive and their purchase is not justified unless much work is to be done. Some augers are driven by their own power units, whereas others are made as attachments for different makes of tractors. A type of gasoline-engine-driven power auger is shown in figure 6.

Figure 6.—Auger, driven by gasoline engine, used for boring holes in stumps to facilitate burning.

In some localities blasting just enough to split a stump, as shown in figure 7, is the first step in the burning operation. This practice can be followed with stumps either with or without tap-roots, and it saves the expense of boring the holes, but generally the center of the stump burns out and leaves sticking up around the outside a number of snags that can be kept afire only by continually piling on brush.

To have a good fire it is necessary that the burning and heat-generating parts be close together all the time, so that little heat will be lost by radiation. A method that produces this condition around the roots, where it is so greatly needed, is to saw the stump off just above the ground, lift the top 2 to 4 inches, and place small stones between the two parts to preserve this distance. As the fire, started in the center of the stump, continues to burn, the weight keeps the top always close enough to the base to reflect the heat from the more flammable top down toward the roots, which is a great help in burning them out.

Figure 7.—Stump split by dynamite to facilitate burning.

The charpitting method of destroying stumps is an adaptation of the methods used in making charcoal. It consists in building a

fire at the base of the stump and so enclosing it that only enough air to support limited burning is admitted and a great part of the heat of combustion retained within the stump. A fire of kindling wood is started between two roots or on all sides. Encircling the stump takes more kindling but makes a better and quicker fire. The bark should be cut away where the fire is to be placed, preferably some weeks before, to have the stump drier. The earth should be dug from the base and roots so that the fire will burn underneath them.

After the kindling wood is in place it should be covered with ferns or leaves with a light coating of 3 or 4 inches of earth, except where the fire is to be started. The kindling should not be more than 18 or 24 inches high. As the wood burns down, the fire will break through in places, and it is then necessary to apply more dirt to keep it covered. As the burning progresses fresh dirt should be shoveled over the fire and placed on the outer edge of the earth bank. Fire that burns above where the dirt is piled should be put out so as to confine it, as far as possible, to the base of the stump. It is necessary that the fire be covered at all times and never allowed to burn into an open blaze, otherwise much heat is lost and the air getting to the fire stops the formation of charcoal in a very short time. When the fire gets into the roots, they also must be kept covered with earth. Clay soils are the only ones that pack and bake satisfactorily.

A charpit fire on a large stump may burn for a month or two, and during all this time it must be carefully watched to make sure that it does not break through the earth seal. Ordinarily two or three times a day is often enough to visit a burning stump, and it is possible for one man to tend a large number after the fires get well started. Resinous stumps with taproots are more easily charpitted than any others, but this method is limited to stumps of considerable size. It is possible to charpit wet stumps even in wet weather, but the results are more apt to be satisfactory when stumps, roots, and ground are dry.

Successful charpitting depends on keeping a great mass of hot charcoal in the heart of the root crown. The fire then burns slowly downward, drying the wet wood ahead of it. This is difficult to accomplish, as the fire is started on the outside of the stump and burns toward the interior, and much care must be taken in regulating the rate of burning. Then, too, the fire is difficult to start, and if it should go out, it is hard to get it going again. A number of devices, ranging from simple plates and draft tubes to stoves that cover the entire stump, have been designed to make it possible to start the fire in the middle of the stump or to permit greater control of the rate of burning.

A large number of stove or hood burners have been used for burning stumps. They usually consist of a sheet-iron hood that completely covers the stump and thus continuously and accurately controls the draft and confines the heat of combustion. Where stumps and ground are dry such hoods are often successful in

burning the roots out completely. They have not been used extensively, however.

From time to time various devices have appeared on the market for burning stumps by forcing a strong draft of fire through them or down into the roots. Some machines do this by producing a vacuum that draws the fire into and through the stump at a rapid rate, and others blow strong drafts upon the fire with the same effects. This rapid burning, however, does not allow sufficient time for the flames to dry and heat the roots so they also will burn. As the destruction of the roots is of vital importance, such forced-draft burners have been generally unsuccessful.

Were it possible to destroy a stump and its roots by burning, and many claim that it is possible, this would be an ideal way to dispose of them, for no large investment of money is involved, and destroying the stump in place does away with piling, burning, and filling up the hole left in the ground. The general opinion, however, is that it is only under the best of conditions that any method of burning will destroy the roots below plow depth. Irrespective of size of stump, it is generally true that it costs more to remove the roots left by one poorly burned than to remove the stump and roots together by other means. The same trouble is found in all burning methods; they require so much close and careful attention and the exercise of so much judgment that it is almost impossible to get labor that will be painstaking and intelligent enough to use them successfully. All these methods of burning are extensively used, however, and each has strong advocates.

PULLING

The many mechanical devices for the use of power in pulling stumps range from the straight pull of a team to that of huge machines with immense power. There are various types of manufactured or commercial stump pullers, differing in design, in source of motive power, and in size. The primary requisites of all types are that they must be capable of (1) developing enough power to do the required work, (2) being operated with safety, and (3) being moved about easily, if not equipped to pull a large number of stumps from one place.

All these pullers except the large machines must be anchored to a substantial stump. Practically all small machines have an anchor cable that is placed around the anchor stump and allows the puller to swing around with the direction of the pull line, permitting the pulling of all stumps within reach of the pull line from one anchor stump. The pull line is fastened to the stump to be pulled with a choker hook. Several kinds of devices called "take ups," equipped with a short cable and choker hook, can be attached to the pull line at any point for pulling stumps close to the machine or for pulling more than one stump at a time. "Cluster cables" can be attached to the end of the pull line for removing a group of stumps with one pull. Pulleys to which are attached short cables with

choker hooks for anchoring can be introduced to increase the power of the pull.

It is easier to pull stumps in light sandy soils than in heavier clays, and generally less power is required when the soil is moist than when it is dry. Green stumps, of course, are much harder to pull than dead ones.

The most economical size of crew is three experienced men with a team and driver. If the crew is inexperienced, two men, a team, and a driver will be better, for the third man, without experience, will be more of a hindrance than a help.

The efficient operation of a stump puller and its accessories requires experience and judgment. It also requires speed, which means that the operator must be able to plan his work ahead and use his equipment so that as soon as the strain is taken off by one stump coming out of the ground, it is taken up by another. It is largely because of the many niceties of adjustment in the use of accessories and the ability to know precisely in what order to pull the stumps that one crew will pull twice as many as another.

Most pullers are arranged for two speeds. The slow speed, having the most power, is used for heavy pulling, while the high speed is used for pulling small stumps and dragging them to a pile. With some designs the speed can be changed while the pull is being made, if desired. Safety is obtained by various automatic locking devices that reduce the liability of accident in case any part breaks.

The operator of any pulling machine or tractor should be protected from recoiling cables due to broken hitches or cables, and all workers should be required to stand in the clear during the pulling operation.

In general, stump pullers are adapted to work under a wide variety of conditions, and suitable types are available for almost every kind of stump removal. The advantages of a stump puller are that it removes all the stump roots that would interfere with cultivation and that with experienced crews the cost of operation is comparatively small. Its disadvantages are that the first cost is high, that it cannot well handle rotten stumps, that it sometimes leaves large holes that must be filled before the ground can be cultivated, and that the pulled stump is so hard to handle after it is on top the ground that further disposal is often expensive.

Chain and Hook

The simplest puller is a chain with a hook on one end and a team of horses on the other. The hook is fastened to, or around, one of the main roots of the stump and placed across the top. The stump acts as a fulcrum, giving a leverage that increases the pulling power of the team. Stumps of considerable size can be removed in this way if the roots are grubbed and chopped off enough to lighten the pull to the capacity of the team.

The pulling power of a tractor can be used in the same way, and it will pull somewhat larger stumps than can be moved with a team. Such work is hard on either team or tractor, and rather than attempt to pull large stumps with such a simple outfit it is generally better to increase the power available. This can be done by using a longer chain, a rope, or a wire cable in place of the short chain, and threading it through one or more pulleys or blocks. A $\frac{5}{8}$-inch wire cable is best, for a rope is usually too weak to stand the continued strain and a chain is heavy and unwieldy. By using one pulley the power can be doubled and two pulleys will treble the power, but the time required to pull the stump is increased, and it also takes more time to attach and fasten the cables and get ready to pull.

Twister

A simple device called a "twister" is used with fair success in some localities. It is a pole beam about 20 feet long of some tough wood, with a chain and hook on one end. The chain is wrapped around the stump and made fast with the hook, and a team, hitched to the free end of the beam, walks around the stump, twisting it until the roots are pulled out or broken off.

Whip

A device called a "whip," illustrated in figure 8, has been developed by the agricultural engineering division of the Michigan Agricultural College for pulling brush, snags, and small stumps. It consists of a cant-hook handle with a $\frac{3}{8}$-inch chain, $2\frac{1}{2}$ feet long, fastened to the large end. The free end of the chain is fas-

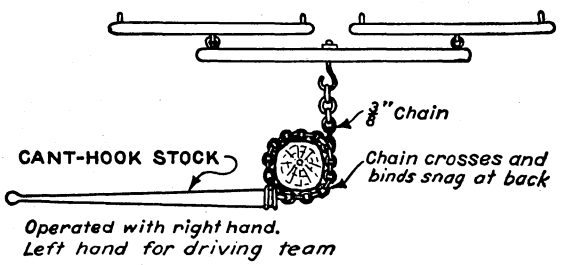

Figure 8.—Chain whip for pulling brush, snags, and small stumps.

tened to the whiffletrees of a team. The operator wraps the chain around the stump so that it is crossed and binds on the side away from the team, and holding the end of the cant hook in his right hand so as to keep the chain rigidly in place he drives the team ahead with the reins in his left hand. As soon as the stump is pulled the chain can be readily disengaged. On small stumps and standing brush this device works rapidly and efficiently.

Mallet Stump Puller

For somewhat larger stumps a "mallet stump puller," shown in figure 9, can be cheaply made with the tools available on any farm. The large mallet head is of cedar or other light wood 18 inches in diameter and 30 inches long, and the handle is of hickory or other tough wood about 6 inches in diameter and 6 feet long. A pull chain 12 feet long is fastened to the end of the handle. It is operated by placing the side of the mallet head against the stump with the handle in an upright position. A heavy chain with

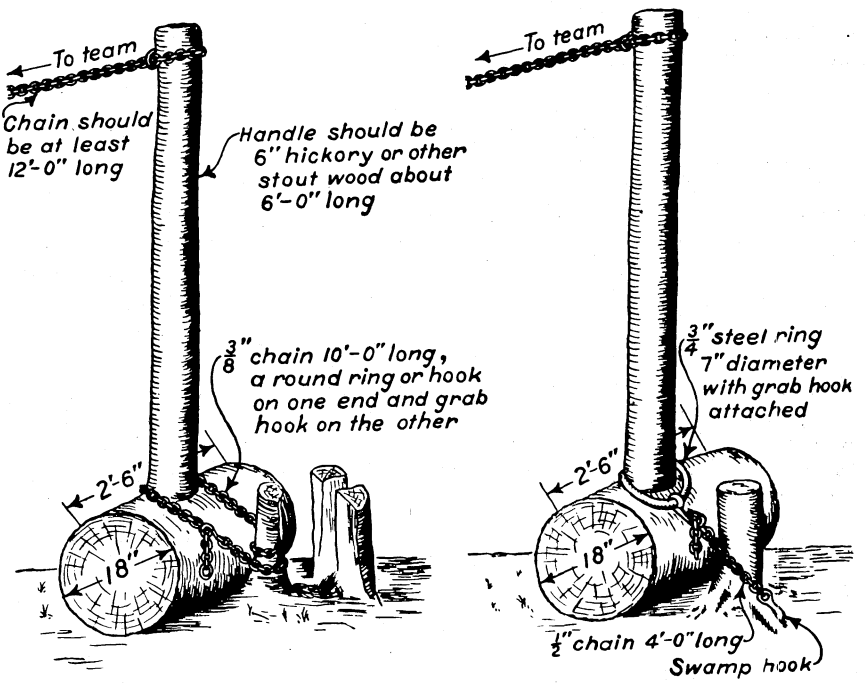

Figure 9.—Mallet stump pullers, one with chain only and one with steel ring, grab hook, and chain.

a "corner bind" or "fid hook" attachment is placed around the stump as low as possible and then around the handle where it enters the log. It is essential that this chain be as tight as possible, since the greatest leverage is obtained when there is no slack.

Pulling the handle down to a horizontal position turns up the stump on the mallet head. The pulling power of the team is increased about six times with this device. Very little strain comes on the mallet head, so the lightest obtainable wood should be used for it, but the handle should be made of tough, strong wood. The 6-inch hole can be made in the mallet head by cutting or burning, but the best way is to bore several small holes within the area of

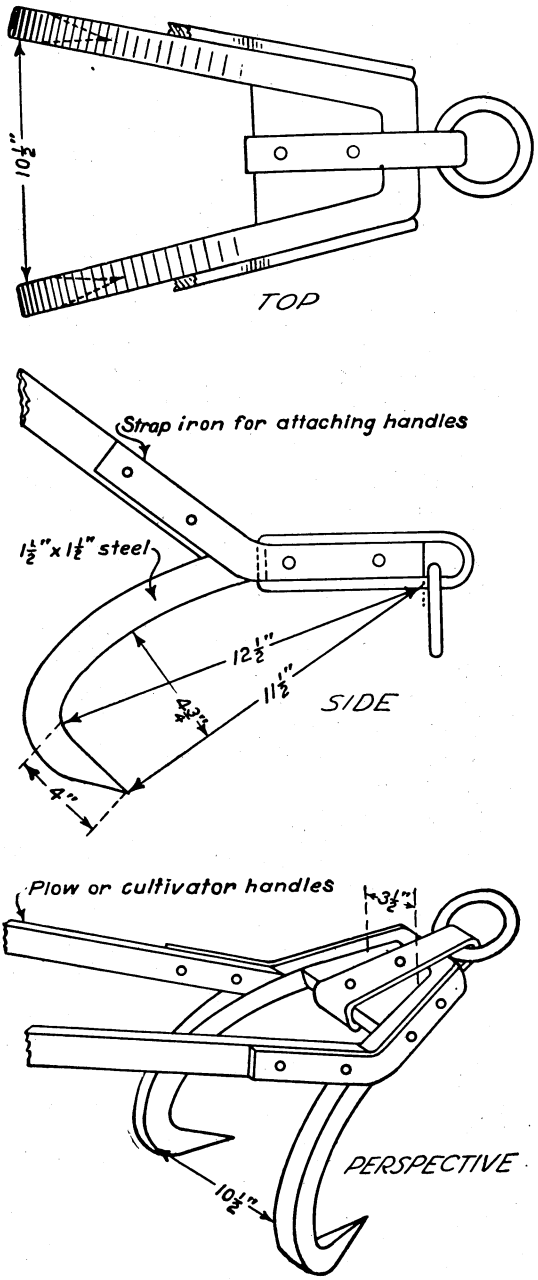

Figure 10.—Root hook, for removing low snags and stumps on which a pull line cannot be used.

the proposed hole and then with a chisel chip out the walls between the small holes. An iron bolt through the mallet head to keep the handle from coming out, an eyebolt at the top of the handle, and some sheet metal at the lower end of the handle to prevent the chain from wearing into it are all good additions but not essential.

Root Hook

Root hooks (fig. 10) are made for pulling roots, snags, or stumps that have been cut too low to allow the pull line to be fastened to them.

Power for Pullers

The motive power of the pullers may be hand power, horsepower, or power taken off tractors or from steam or gasoline-driven engines. The hand-power pullers are of two types, the clutch and the drum. In the clutch type the pull line is gripped by a steel clutch and pulled in by means of a lever worked by hand. In the drum pullers the cable is wound around a drum that is turned by a hand lever. The power of the hand pullers is increased where necessary by means of pulleys so that large and heavy stumps can be pulled, but their speed is much slower than pullers that have more power. Of the two types the drum has a greater power within itself. With the clutch type, however, it is possible to clear a greater area from one anchor stump, to dispose of the slack cable more easily, and to make the hitches somewhat more easily because of the lighter cable.

Hand pullers are adapted for work where the stumps are small or widely scattered, where the number to be pulled is not large, or where other sources of power are not available or cannot be used, as in swampy or rough ground. Two men make the best size of crew under average conditions, although all the work can be done by one man if necessary. Either type requires hard and tedious labor, so much so that a man can hardly operate one continuously. Hand pullers weigh from 100 to 400 pounds, the heavier ones being mounted on small trucks or wheels.

The principal difference in the design of horsepower pullers lies in the direction of the pull, vertical or horizontal, exerted on the stump. Some years ago the tripod puller, which exerted a vertical pull, was used extensively, but for the last several years few have been sold in this country. The vertical puller had great power and exerted it in the line of least resistance, but the machine was hard to move on account of its shape and necessarily heavy construction, it had to be moved for each stump pulled, and its operation was slow. The pullers in use at present exert their pull in a horizontal direction by means of a cable wrapped around a vertical drum and turned by a team working at the end of a sweep.

Having more power in the team and greater leverage in the sweep than is possible in the hand pullers, the horsepower machines have much greater power and so can pull stumps of considerable size without introducing cables and slowing up the speed.

The power of the team is usually multiplied 25 to 30 times with a simple pull line, and this power can be doubled or trebled by introducing one or two pulleys.

Most makes of horsepower pullers are equipped with long anchor cables, which allow the team to pass between the anchor stump and the machine, avoiding the necessity of cutting off the top of the anchor stump to allow the sweep to pass over it. A horsepower puller in operation is shown in figure 11.

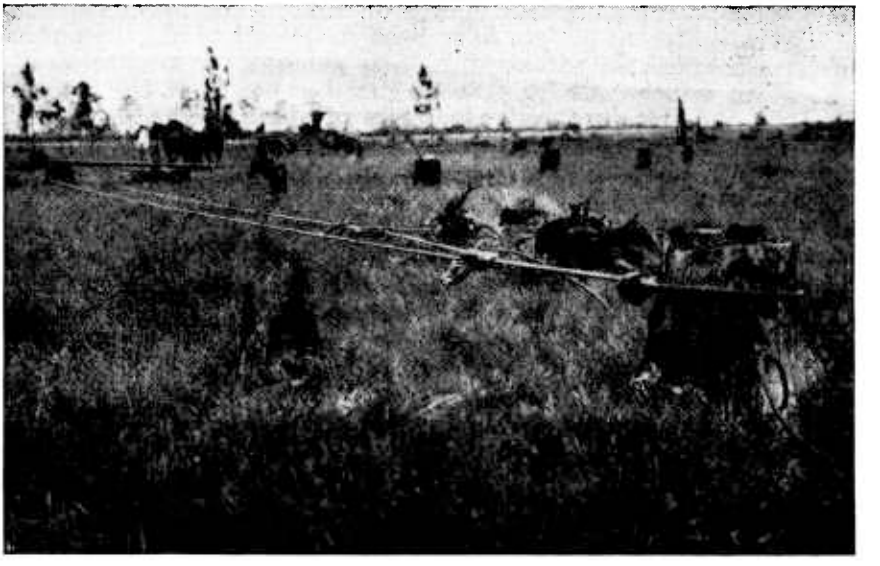

Figure 11.—Removing stumps with horsepower puller.

It is not necessary or economical to buy a machine that will pull the largest stumps in the field, as the heavy cables will have to be used in pulling the small as well as the large ones. The cost of the entire operation will be cut by getting a puller of a size that will readily take out about 60 percent of the stumps and by using explosives to loosen up the larger ones until they can be removed by the machine.

By stopping the puller and holding the strain just as the stump is being turned over on its side, a man with a grub hoe can knock off a good deal of the earth that clings to the roots so that it will fall back into the hole. Using explosives to loosen the stumps makes the roots come out free from dirt.

Horsepower pullers weigh 100 to 1,500 pounds and vary in price, depending on the size of the machine and the equipment furnished. An outfit for medium work would probably include, besides the stump puller, 100 feet of pull-line cable, the size depending on size of machine (probably ¾-inch), two power pulleys, three take-ups, a long anchor cable, one or two extension cables for

lengthening the pull line, and a root hook. Other tools required are ax, grub hoe, crowbar, and shovel.

Horsepower pullers can remove almost any stump, especially with the aid of explosives in loosening up the largest ones, but their economical use is limited to situations where the number of stumps is large enough to justify the investment of a considerable amount of money. Work can be done most economically where the stumps are thick and of uniform size so that they can be pulled by the machine without the aid of pulleys and where a high type of labor is available to take charge of the operation.

Several different pullers have been developed to use the power of farm tractors for pulling stumps. In general, the machines consist of an attachment for transferring the power of the driving shaft of the tractor through a series of gears to the shaft of a horizontal drum around which the pull line is wound. Some types have two drums and two speeds, as shown in figure 12. A trans-

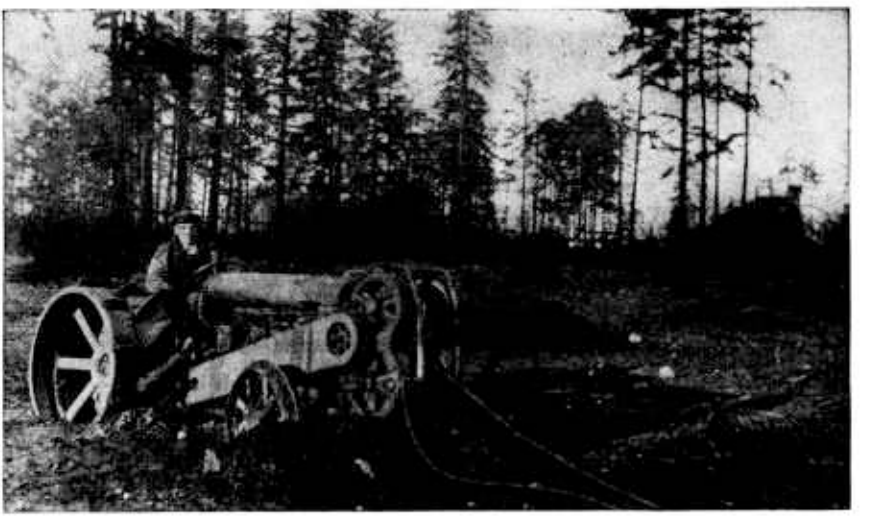

Figure 12.—Tractor with two-drum attachment for pulling stumps.

verse runner, or shoe, is generally put under the tractor base, which allows the machine to skid around the anchor stump following the direction of the pull line. Pulleys may be used in the pull line to double or treble the power when necessary, as in the horsepower pullers. These attachments are variously priced but probably average about $500.

Some types of large machines use the power of their own steam, gas, or kerosene engines. These develop a great deal of power, so that stumps can be pulled rapidly without using pulleys, and can work over a large area from one set-up. They are generally pilers as well as pullers, since most of them are equipped to pull the stump and also drag it into a central pile.

The large machine most commonly used is called the "donkey engine"—an adaptation of logging machinery and methods for stump removal. It consists of a hoisting engine, either steam or gas, with at least two drums. The equipment on the larger machines includes 1,000 feet of 1⅛-inch pull-line cable, 2,000 feet of ⅝-inch haul-back cable, four 1-inch guy cables, two 10-inch blocks for gin pole, four 8-inch blocks for the haul-back line, lead lines, and chokers.

A large machine with such equipment can clear stumps from a 10-acre tract at one set-up. The engine is usually placed at the center of the area and a gin pole, sometimes 100 feet high, is erected a short distance in front of it. The pull line and the haul-back line are passed through blocks near the top of the gin pole, and the haul-back line is passed around a part of the land in front of the engine, going through pulleys at the corners of the area, and is then fastened to the end of the pull line. A stump, to which is fastened the pull line by a short piece of cable, is pulled in to and upon the pile, the haul-back cable running out freely, and when the stump has been dropped onto the pile the haul-back cable is pulled in and this draws the pull line out again. Explosives are usually employed to split and loosen the larger stumps.

Smaller machines with less power have been used. These cover a smaller area from one position and follow the same plan of work, but it appears that in this type the larger machines are the more economical. Such machines can only be considered where the stumps are large and numerous and where the area to be cleared is sufficiently great to warrant a large investment. The principal field of usefulness of this type of machine so far developed is the Pacific Northwest.

Hints for Beginners

The following hints for a beginner with a horsepower outfit are very good:[4]

1. Set puller on level ground, higher than stumps to be pulled, if possible, so cable will be low enough for team to pass over. Select stout anchor stump. With ax cut notches for anchor cable close to the ground.
2. Crack any large stumps with small charges of dynamite if they are too large to handle or if they will bring up too much soil. Place charges shallow and close to wood of stump for splitting.
3. Fasten cable on stump so no sharp bends are made to weaken or bend it. Hook as high as possible on stump to be pulled and thus get leverage.
4. Use grub hoe on earth clinging to roots just as the stump comes from the ground while it is over the hole. It pays to stop the team and knock off the soil.
5. If cable seems to be coming off stump before it is pulled, throw a chain around an exposed root and hook to cable ahead of

[4] From Wis. Agr. Expt. Sta. Cir. 148, Keep the Stump Puller Working.

take-up. A short cable with hooks on each end works well here, too. This scheme is also good with the root plow (root hook).

6. Dig a place to tie chain around blind stumps and small roots. Use grub hoe to make a good place to hook root plow.

7. A block of wood or piece of stump thrown in front of the top of the stump as it falls after being pulled will make it easier to remove cable from pulled stump. The other take-up can be put on an exposed root and stump tipped over again to remove cable, which sometimes gets fastened.

8. Grease puller carefully. Grease old cable with oil-soaked waste or rags. Grease will soon soak in and cable will be smoothed up. Grease cable when not in use.

BLASTING

Explosives are widely used for blasting stumps entirely out of the ground, for loosening up large stumps before pulling, and for splitting stumps that have been pulled.

It is the writer's opinion, based upon observations of stump-blasting methods in all the agricultural States, that the average man wastes about one-third of the explosive he uses in blasting stumps. A loud sharp report, stump pieces thrown high in the air, and a large crater left in the ground are sure evidences of wasted explosives. To obtain the best results with a minimum of explosives, the charge should be well down in the ground, under the center of resistance of the stump, and the borehole above the charge should be well and thoroughly tamped with moist clay.

The electric method of firing is preferred to the use of cap and fuse because of its greater safety and because much better work can be done, especially with large lateral-rooted stumps.

The advantages of blasting stumps are that (1) little investment of capital is necessary, (2) the labor required is small, (3) the stumps are thrown out free of earth and split up so that they are easily handled, (4) operation can be carried out in any kind of weather, and (5) it is equally available for few or many stumps widely scattered or close together.

The disadvantages of using explosives are that they cost money and that sometimes they leave large holes in the ground after the stump has been blasted out. ***There is, too, an element of danger always and inseparably connected with the use of explosives. Only men experienced in handling explosives for blasting stumps and in the use of powder should be permitted to do such work.***

BULLDOZING

Since about 1935 there has been a remarkable increase in the use of bulldozers for land clearing. This method has largely superseded others in the Lake States and in the Pacific Northwest. A bulldozer in its simplest form is an adjustable vertical cutting blade attached to a tractor. Some blades are equipped with teeth,

and some, as shown in figure 13, have an adjustable arm projection used for raising or splitting the stump. The method of operation is simple. The blade is shoved forward until the stump is pushed over. It is necessary to do some preliminary root cutting with the bulldozer blade before a large stump can be uprooted. Small dynamite charges may be used for loosening large stumps. The bulldozer is used also for piling stumps and for grading and smoothing the field after the stumps are removed.

Figure 13.—Bulldozer used for uprooting stumps, brush, and small trees. The guard over the operator is important for preventing injury by trees falling backward across the machine.

These machines are much too expensive for the individual farmer. Consequently bulldozers now operating are owned by contractors or farmers' cooperative organizations. Some counties make such equipment available to farmers for land clearing. In most cases the owner furnishes the operator and pays all operating expenses, charging the farmer a flat rate per hour of operation. The cost per acre varies greatly with the number and size of stumps and with the amount of piling and grading done, but the average cost per acre on 6,000 acres in the Upper Peninsula of Michigan in 1937 was $8, whereas in western Washington the cost in 1939 ran from $35 to $50.

DECAY

In some sections stumps in cultivated fields are left until they become so rotten that they can be knocked over with an ax. A number of stumps—oak, ash, hickory, and gum—will rot so that they can be easily removed in 5 to 10 years; but others—pine, fir, cypress, poplar, and cedar—will not decay to an appreciable extent for many years.

The process of decay can be hastened by introducing poison into the circulatory sap system of the living tree. A number of poisons of varying degrees of strength are available. One that gives good results is composed of 1 pound of white powdered arsenic, 2 pounds of lye, and 2 gallons of water. To prepare the poison, first make a paste of the arsenic by adding a small quantity of water. Put the lye into 1 gallon of water slowly, stirring as it is added. The dissolving lye heats the water. When all the lye has been dissolved, and while the water is still hot, add the arsenic paste, a little at a time, stirring until it is all dissolved, then add the second gallon of water. If it is desired to mark the trees that have been poisoned, add 1 pound of whiting to the solution. Two gallons of poison will be sufficient for about 30 trees averaging 15 inches in diameter. The arsenic in small lots costs 30 to 50 cents a pound and the lye about 15 cents.

To apply the poison cut a continuous ring of gashes around the tree about 2 feet above the ground, penetrating through the first and second barks and into the sapwood. The cuts should be made as shown in figure 14, so that they will retain the poison rather

Figure 14.—Decay of a tree can be hastened by applying poison in gashes cut around the trunk.

than permit it to run down the outside of the bark. Pour the poison into the cuts, using an old teakettle or coffee pot with a long spout for convenience in applying. The solution should be stirred frequently to prevent sedimentation. Three men can ring and poison about 200 trees per day.

Extreme care must be taken in handling this poison. The fumes given off during mixing are deadly and must not be inhaled. Cattle should be kept out of fields for a few days after application, as they might lick the poison out of the cuts. **Chemical analyses of the withered leaves show that cattle would not be harmed by eating them.** ***Utensils that have been used in preparing or applying the poison should be destroyed immediately after the work is completed to prevent their use for other purposes.***

Opinions differ as to the best time of year to apply the poison. Some say in spring, when the sap is rising, or in summer, while the sap is up in the tree, whereas others say that the best results, especially as to killing sprouts and suckers, will be obtained late in fall. Theoretically, the best time to apply the poison is in spring, just about the time the buds are forming. The poison takes effect more quickly on bright sunny days than on dark or rainy ones.

The poison will cause the leaves of the trees to wither and fade within a couple of weeks, and the process of decay then goes on rapidly in some species, though more slowly in others. In one case of 208 trees of various species poisoned in spring the trunks of 77 had fallen within 1 year, in another case of 46 trees 27 had fallen within 15 months. It is probable that under favorable conditions the stumps of trees remaining 2 years after poisoning could be removed with small expense.

The poison recommended on page 30 seems to kill most species of trees except pines and resinous woods, although the action is quicker with some species than with others. Records kept of the poisoning of various species, using a number of different poisons, show that 9 months after poisoning the trees were affected in about the following order: Hackberry, elm, oak, ash, soft maple, willow, alder, persimmon, hickory, and pecan, the hickories and pecans showing the smallest percentage of deaths. It is possible that after a few more months trees of most of these species would be dead. In another case the white, slippery, and red elms, sweetgum, hackberry, ash, redbud, Osage-orange, and red locust trees were all dead 15 months after poisoning. The wood of a poisoned tree is discolored and becomes soft and punky, so that it is of no value as lumber and makes poor fuel.

Poison cannot be used successfully on stumps. Unlike a tree, a stump has no complete circulatory sap system so that there is no way in which the poison can be circulated through it. Some species of brush can be killed by spraying the poison solution on the leaves, although more than one application may be necessary. In some cases brush can be killed by cutting and then covering the freshly cut stubs with poison.

A number of commercial tree poisons now on the market are used in the manner described above and with practically as good results. They can be purchased ready to apply or requiring only dilution with water.

The advantage of leaving the stump or tree in the field until it decays completely is that this decreases the first cost of land clearing. The disadvantage is that the presence of the stump or tree in a cultivated field during the time required for it to decay so decreases the area of land available for crops and so increases the cost of cultivation that the first saving is usually more than counterbalanced. If there is no money available for removal it is better to poison the trees than to allow them to continue to grow, as the time required for decay is somewhat shortened by poisoning.

DISPOSAL OF STUMPS

Not the least of the problems in clearing land is the disposal of stumps after they have been removed from the ground. Experience shows that it usually costs about as much in time and money to destroy a stump as it does to pull or blast it. Unless the stump can be removed from the field, it is better to leave it in the ground.

Stumps can be dragged from the field and dumped into ravines or gullies or piled on ground too stony or rough for cultivation. The use of stumps for fences has happily almost disappeared. Such fences were not only a blot upon the landscape but they occupied much valuable space that could not be cultivated or kept free from weeds and rodent infestations.

The stumps can be dragged along the ground or loaded onto a sled, stoneboat, or wagon. A sled that has been used extensively in Georgia is 4½ feet wide by 8 feet long. It is pulled alongside the stump, the roots on the side next to the sled are cut off, and the stump is rolled onto the sled.

PILING AND BURNING

Stumps are usually disposed of by piling and burning, though the operation is not so simple as it sounds. It is first necessary to gather them into piles. When they are small or have been well broken up by blasting this is usually done by dragging the pieces to the pile with a team. A small pile is begun by rolling and skidding a number of stumps together. When the pile gets too high to roll the stumps on by hand, a long chain is thrown over it and the stumps are hitched so as to roll them up on the pile by team or tractor.

More elaborate means may be necessary where the stumps are large and numerous, and lines drawn in by any of the various types of hoisting engines can be used for this purpose. The stumps can be lifted onto the pile by a cable reaved through a block at the top of a tree, gin pole, or portable derrick. Generally some form of gin pole is used on account of its cheapness and ease of handling. The Conrath piler (fig. 15), which has been used extensively in

Wisconsin, requires very little blacksmithing and can be built cheaply. Any device for lifting stumps onto a pile should have some kind of trip to release the stump at the proper time. The Frost trip (fig. 16), also developed in Wisconsin, gives very good satisfaction and can be made cheaply by a blacksmith.

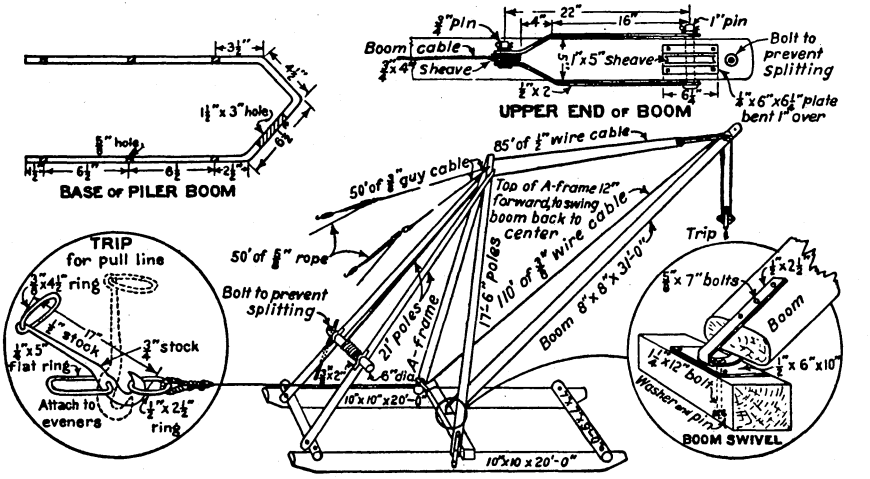

Figure 15.—Conrath stump piler, made largely of wood, with a little blacksmithing.

When large stumps have been pulled they must generally be split with explosives for easy handling, for removing earth from the roots, and for building a more compact pile. The removal of the earth from the stump before piling is of special importance, for often so much clings to the roots that it is impossible to move or burn them. One of the best methods of splitting a stump is to bore a 1½-inch hole into it just above the crown and inclined downward toward the center, deep enough for placing the center of the charge just past the middle of the stump and for leaving at least 8 inches of space above the charge in the wood for the stemming, but not deep enough to approach too closely the opposite side of the stump. Some prefer to bore the hole in the top of the stump, at its center, directly toward the roots and about 18 inches deep. The power augers described on page 16 may be used for boring. Where no augers are at hand, a "mudcap" charge, or "dobie shot," may be placed between two of the large roots where they join the stump.

The piles should be made as compact as possible, small at the base with considerable height (fig. 17), rather than low and wide. They should not be too large, for the heat may be so intense as to injure the fertility of the ground underneath. The maximum size depends upon the kind of stumps burned, which largely influences the amount of heat thrown off, and the type of soil. Some authori-

ties say that five large resinous stumps will make a fire hot enough to injure some kinds of soil appreciably. It is very important that as much earth as possible be removed from the roots before piling them, as the earth interferes to a marked extent with obtaining a good fire. Some prefer to start the fire at the top of large piles rather than at the bottom, as they say this method requires less work in getting a complete burn.

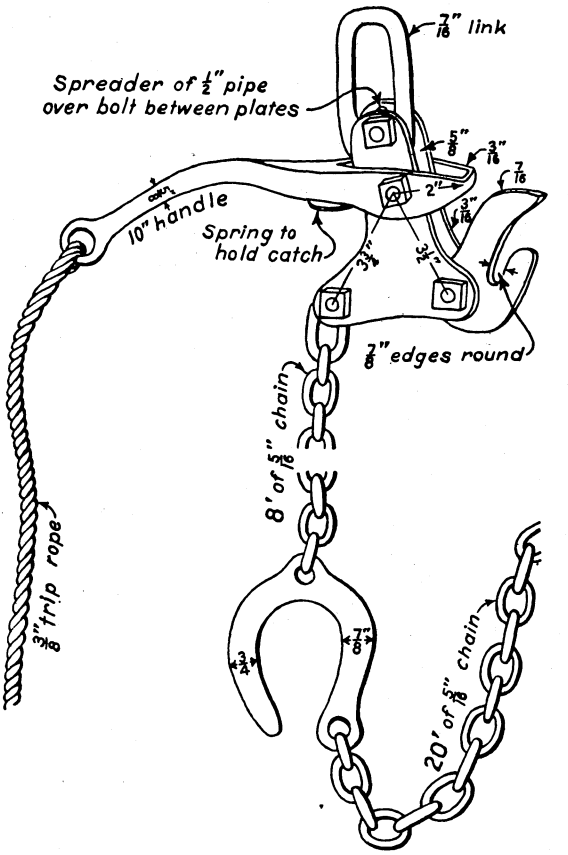

Figure 16.—Frost trip.

SELLING

Probably no one has watched the burning of a large stump pile without wondering whether some use might be made of the wood instead of wastefully destroying it. A great many investigations of this problem from different angles indicate that there is no profitable use that can be made of the greater part of the stumps now being destroyed.

In some sections there is a sufficiently large demand for firewood to pay the cost of splitting up and delivering the stump wood. This is true in certain parts of the South, where the fat lightwood stumps can often be sold for enough to pay the cost of removal, but in most areas, especially where stumps are abundant, firewood is still so plentiful that there is no market for stump wood for this purpose.

Figure 17.—Stumps piled so as to burn readily.

It would seem to one unfamiliar with all the ramifications of the naval-stores industry that the resinous pine stumps could be distilled and the products profitably marketed, but investigation shows that generally such operations cannot be profitably conducted at present. It appears that the pine stumps of the North and West are not sufficiently rich in resinous oils to make them useful for this purpose now,[5] and that the profitable production of turpentine and its byproducts is limited to the longleaf pine stumps of the South.

There are 2 different methods of obtaining valuable distilled products from longleaf pine stumps—the steam- and the destructive-distillation processes. The steam-distillation process manufactures wood turpentine, pine oil, and resin. It is essentially a large-scale operation, and there are 10 large plants of this kind in various parts of the South. The destructive-distillation process is

[5] U. S. Dept. Agr. Bul. 1003, The Distillation of Stumpwood and Logging Waste of Western Yellow Pine.

adaptable to either large or small plants. The large ones make wood turpentine, pine oil, acetic acid, tar, and charcoal. The smaller ones generally carry their processes no further than a pine oil that contains all the liquid distillate, and charcoal. Scattered throughout the South are 6 large plants of this type and many small ones.

The destructive-distillation process is seemingly adapted to the owner of a few hundred acres of stump land who may wish to get out his own stumps and distill them, but few operations of this kind have been successful, largely because of the limited market available for the products. Numbers of research workers have been engaged in studying this problem, and whenever some substance that can be sold in large quantities at a fair price is found in the distillate, the problem of disposing of the longleaf pine stumps will be solved.

There is now some demand for stump wood in areas adjacent to the large plants. The prices obtainable depend largely on the distance of the wood from the plant and the railroad facilities for shipping it. One plant uses the stump wood from 50 acres each working day, and several others are almost as large, so that when the plants are running full time the total area required in a year has been estimated at 100,000 acres. The larger plants obtain most of their wood by leasing stump lands at nominal figures and removing the stumps with their own forces. One disadvantage in leasing stump land to a distillery arises from the tendency to leave the taproot in place, owing to the expense of getting it out, so that the landowner often has to spend more money in removing it than the disposal of the entire stump would have cost. Contracts should definitely specify that the taproot shall be removed to a minimum depth of 18 inches.

Other plants buy fatwood from the owners, some paying for it by the ton and others by the cord. The average weight of a cord of fatwood is about 3,300 pounds. Before the wood can be sold it must be worked up into suitable sizes. Steam distillers take pieces up to 8 by 8 inches by 4 feet, while for destructive distillation the maximum size is 4 by 4 inches by 4 feet. When the stumps are blasted out they will generally be split by the blast into sufficiently small pieces. To make certain of this, a rather faster explosive than might otherwise be used should be employed. Stumps 14 inches in diameter will yield about 400 pounds of fatwood.

Usually there is as great a tonnage of fatwood in fallen logs as in stump wood. The prices paid for both are variable when delivered at a plant. An acre in southern Georgia will yield on the average about 8 tons of each. Until a stump is 6 years old there is so much sapwood in it that it does not pay to distill it, but from that age on to at least 20 years it does not deteriorate, although each fire that burns over it destroys some of its value. Generally a considerable number of stumps and logs on the land are not rich enough to be sold for distillation but must be removed before the land is finally cleared.

Detailed and extensive investigations demonstrate that under present conditions there is little profit in distilling any of the hardwoods or nonresinous conifers to produce wood alcohol, other chemicals, or charcoal. Generally, then, it seems that it is necessary to destroy the stumps, as there is at this time no profitable use to which they can be put, and the space they occupy is needed for the production of crops.

CHOICE OF LAND-CLEARING METHOD

In brushing where there is no immediate necessity for cropping the land it is generally best to burn it over, cut down the remaining trees and brush, seed it to grass, and pasture heavily for 2 years or more. This treatment will not only destroy most of the brush but will greatly lessen the cost of removing the stumps, and during the period of pasturing the grazing stock will be productive. Where it is desired to begin the cultivation of the land at once it should be burned over and the remaining brush and trees cut down, piled, and burned.

For stump removal the conditions are more varied than for brushing, and consequently a greater number of factors govern the choice of method to be used. The most important of these is that many farmers are without funds to invest in the necessary equipment. In such cases grubbing, use of homemade pulling devices, burning, and blasting are the only available methods.

Although blasting does require the investment of some money, it is included, for a man may very well be able to buy a hundred pounds of dynamite for use on the large stumps when he would be unable to buy a stump puller. A man in this situation would resort to grubbing, for this is the cheapest method of getting small stumps out, especially when slack-time labor is used. As the size of the stumps increases, he will use his team or tractor and homemade pullers, and the very large stumps he will split with explosives or blast them out entirely. He will use the burning method only for resinous stumps in clay soils and where labor is sufficiently careful and painstaking to insure destruction of the roots.

The choice of methods for the removal of scattered stumps, either in cut-over areas or in cultivated fields, is limited generally to grubbing, to pulling with teams, tractors, or light pullers, and to burning or blasting because so much time is lost in moving heavy equipment among widely scattered stumps that their operation is not economical.

The man who has only a small number of stumps to remove cannot afford to invest heavily in equipment, so that he too must choose between grub hoe, mallet puller, fire, or explosives.

In many localities types of power pullers can doubtless be rented for a nominal fee. If the work does not justify the purchase of a power puller, a horsepower puller and heavier equipment might be advisable.

Where large areas are to be cleared, all the methods and equipment reviewed in this bulletin, as well as other heavy machinery (not described, on account of its limited use), may be employed. The selection of the method in this case should be made only after a careful balancing of a large investment, heavy operating costs, and a large daily output, on the one hand, against a small investment, small operating costs, and small areas cleared daily, on the other.

In general, stumps are most economically disposed of by piling and burning, and the methods of handling and piling will depend upon the size and number of stumps.

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